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RESEARCH AND DEVELOPMENT TECHNICAL REPORT

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LEVEL II

ANNEALING OF BORON-IMPLANTED SILICON BY A HEAT-
ASSISTED NONCOHERENT LIGHT FLASH

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JUN 23 1981

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MAY 1981

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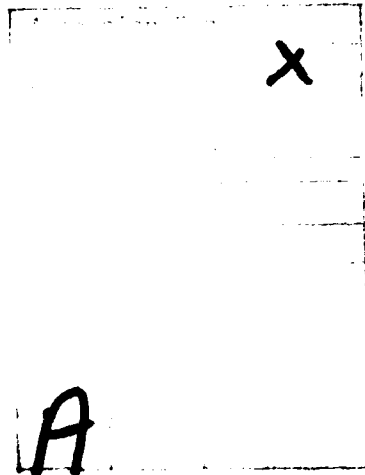
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FIGURES

1. (Top) Surface spreading resistance of annealed silicon versus distance measured perpendicular to the lamp in the sample plane. (Bottom) Energy fluence from a single flash versus distance measured perpendicular to the lamp in the sample plane using a 2 mm wide calorimeter. 2
2. Concentration of electronically active boron in silicon versus depth obtained from spreading resistance measurements in two annealed samples. 3



INTRODUCTION

Shortly after high speed annealing techniques came into use, several studies 1, 2, 3 showed that flashlamps could be used to produce annealing of ion implanted semiconductor materials similar to that obtained using lasers or electron beams. However, these systems suffered many problems which made the application difficult to imagine. Among these were the small size of the annealed spot and damaging shock waves which shattered samples and lamps, to name just a few. Results obtained using a linear quartz lamp, together with those reported by Correra and Pedulli 4, show that quartz flashlamp anneals with a pulsewidth of about 1 msec can be used for convenient initiation of reproducible solid phase epitaxial regrowth in silicon.

DISCUSSION

The lamp used in this work was a commercial linear quartz xenon lamp (EX-121). Its outer diameter is 0.9 cm and the gap distance 7.5 cm. With a 100 microfarad condenser battery and 400 microhenries in series, a non-oscillatory light pulse of 0.9 msec FWHM was obtained. The silicon sample, 1 cm by 1 cm, was mounted on a flat heater spiral of low thermal mass and was placed at 1 mm distance from the flash tube (1.4 kV operating voltage). The light fluence was measured with a narrow strip calorimeter to be 25.6 joule/cm² at the closest approach to the lamp. The samples used for the annealing experiments were n-type 1 ohm-cm(111) silicon, implanted at room temperature with 10¹⁵/cm² 50 keV boron. The samples were brought from room temperature to 750 C in 20 seconds at which time the lamp was flashed. Some samples were exposed to multiple annealing cycles, allowing samples to come to room temperature between cycles.

Samples were evaluated by two techniques of spreading resistance measurements: (1) surface measurements to determine the lateral uniformity and (2) depth profiling to determine the distribution of the boron after annealing. Figure 1 shows surface scans perpendicular to the lamp axis. The 2 mm wide low-resistance valley is indicative of the lateral extent of good annealing. Figure 2 shows a depth profile of the boron concentration measured in the low resistance valley. Comparison of the measured profiles with the LSS model as-implanted profile indicates modest boron redistribution during the anneal. In the multiply-exposed samples, no lateral growth of the annealed area was seen, while some spreading of the boron profile occurred. A narrow calorimeter was scanned laterally to measure the energy incident on the wafer surface with results shown at the bottom of Figure 1. The observed area of good annealing corresponds to an energy fluence of greater than 25 joule/cm². It can be seen that the output of 9 lamps in a closely packed array will produce the same energy fluence over a 3-inch wafer.

ACKNOWLEDGMENT

It is a pleasure to thank Mr. A. Mark of ERADCOM for preparing the samples and Dr. J. Ehrstein of the National Bureau of Standards for performing the spreading resistance scans and for many valuable discussions.

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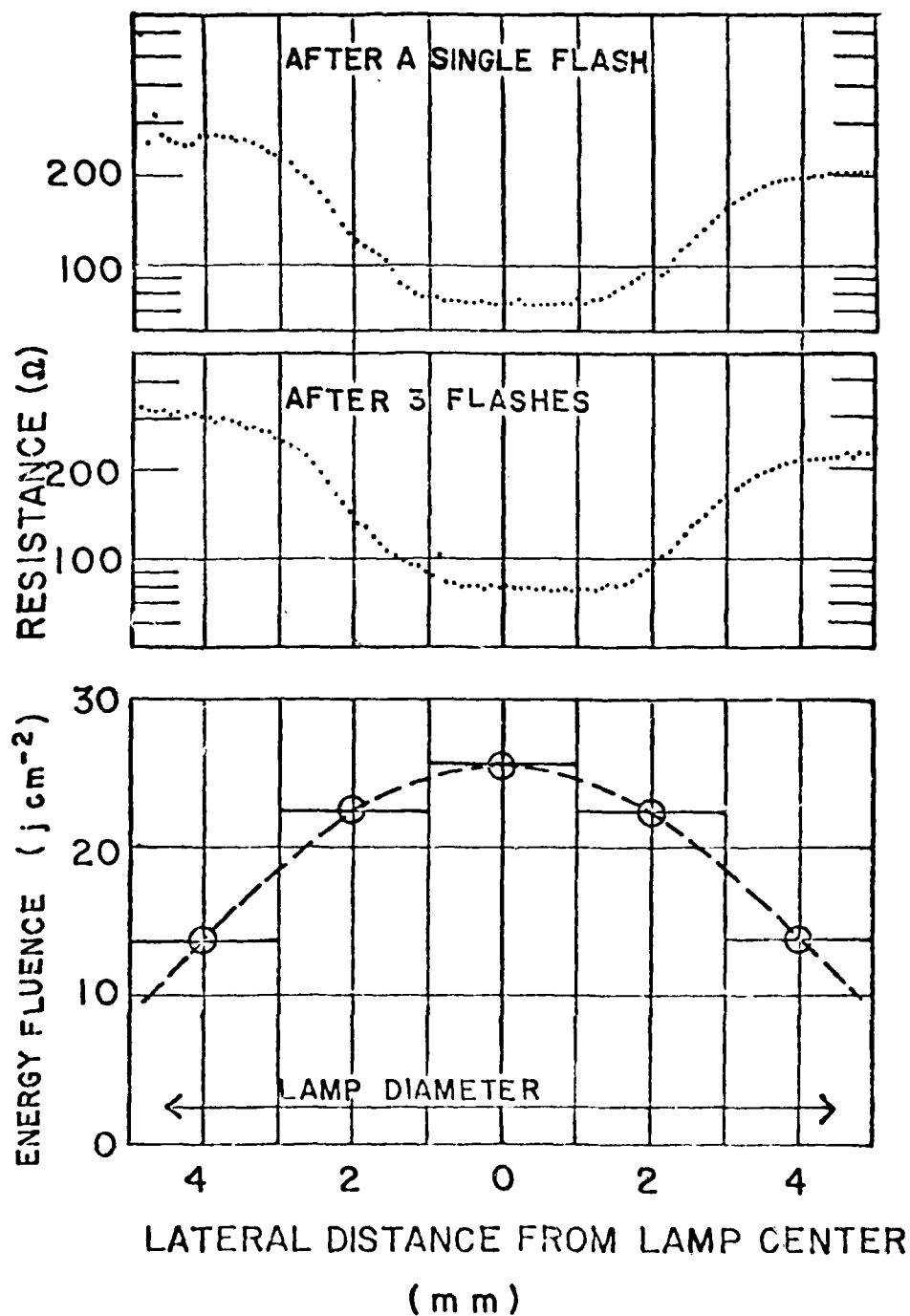


Figure 1. (Top) Surface spreading resistance of annealed silicon versus distance measured perpendicular to the lamp in the sample plane. Samples were exposed 1 mm below the 9 mm diameter flashlamp. (Bottom) Energy fluence from a single flash versus distance measured perpendicular to the lamp in the sample plane using a 2 mm wide calorimeter.

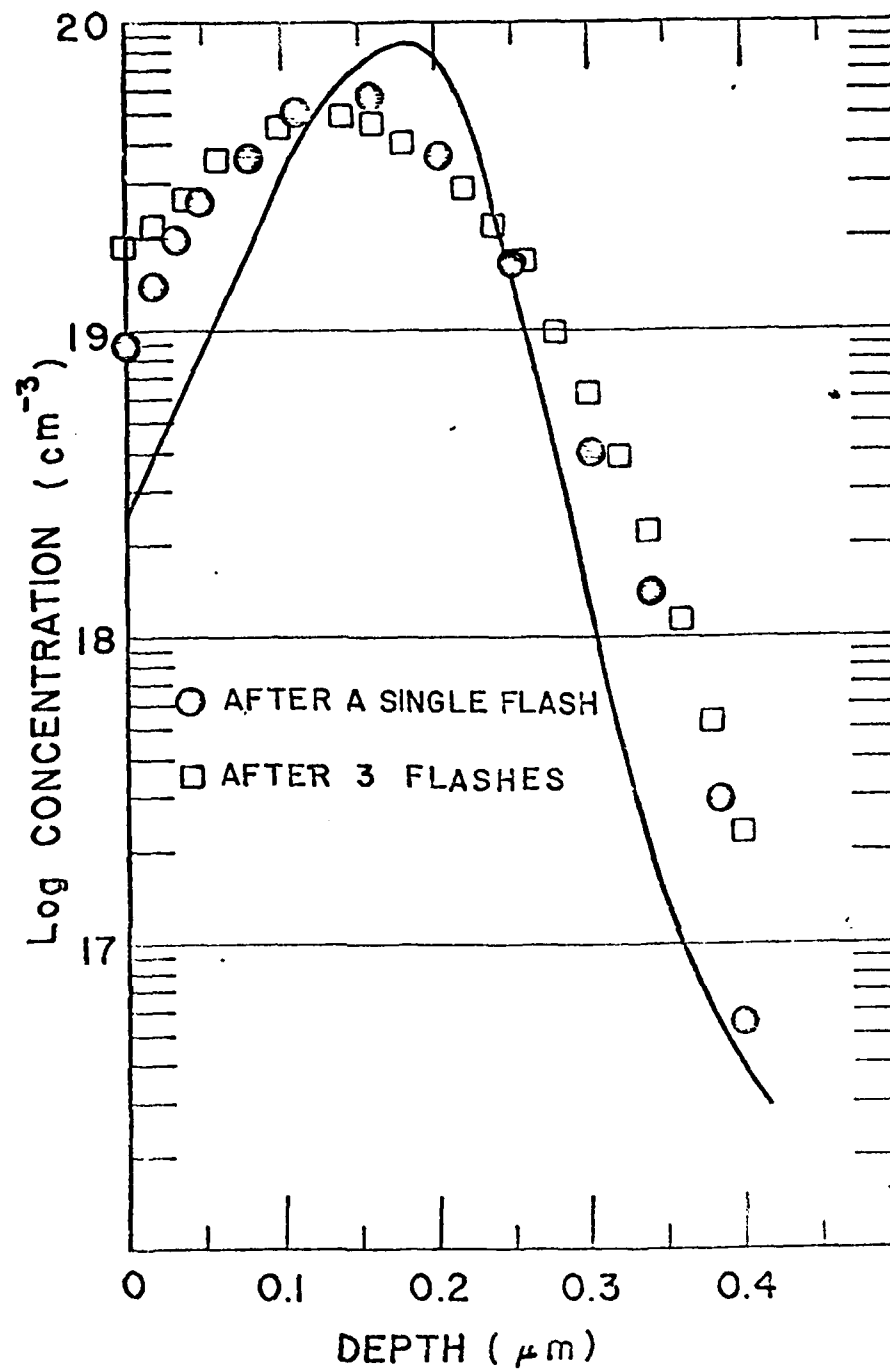


Figure 2. Concentration of electronically active boron in silicon versus depth obtained from spreading resistance measurements in two annealed samples. The solid line is the implanted boron profile (Edgeworth distribution calculated from the LSS model, Reference 5).

5. J. F. Gibbons, W. S. Johnson, and S. W. Mylroi, "Projected Range Statistics; Semiconductors and Related Material," 2nd Edition Dowden, Hutchinson & Ross, Inc. (1975)

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